February 4, 2003

Ms. Jennifer Hutchison
Indiana Department of Environmental Management
Office of Water Quality
2525 North Shadeland Avenue
Indianapolis, IN 46219

Dear Ms. Hutchison:

RE: Source Identification and Assessment Report
ARN No. A305-1-01-276-1-0
Triad Engineering Incorporated Project No. I023557

Per Task 7(a)(b) and Task 9 of the Supplement to Master Agreement for Technical Services between Triad Engineering Incorporated (Triad) and the Indiana Department of Environmental Management (IDEM), the following text and attachments present an evaluation of surface water sampling data assembled by Triad, HydroQual, Inc., and TN & Associates, Inc. for development of an *E. coli* bacteria total maximum daily load (TMDL) for the Trail Creek watershed located in LaPorte County, Indiana. The methods for data analysis and evaluation of results are detailed below.

ANALYSIS OF HISTORICAL DATA

The purpose of this effort is to understand the water quality conditions causing the *E. coli* impairments in the Trail Creek watershed. The ultimate goal is to help determine which modeling approach will be the most adequate tool for providing the TMDLs for the impaired river segments.

The site plan (Figure 1) presents the Trail Creek watershed, each sampling location with river mile designation and data source, general land use (i.e., developed, agricultural, forested, transitional, or wetland), potential nonpoint sources of *E. coli* such as dairy/steer farms (confined feeding operations; CFOs), permitted discharges (point sources such as combined sewer outfalls), and pertinent cultural features (e.g., concentrated septage outside of main developed areas, landfills, dumps) located in the Trail Creek watershed. The discharge point for the east and west sub-watershed branches of Trail Creek (zero river mile) is the point where they intersect with the main sub-watershed branch (near the Daphne Mobile Home Park in Figure 1). The discharge point for the main branch is Lake Michigan. A summary of the 31 *E. coli* sampling locations along Trail Creek according to their river mile designation and general watershed location is presented below:

Sub-Watershed Branch/ Tributary	Sampling Point River Mile Designation
Washington Park – Station No. 410 (Lake Michigan shoreline)	-0.12M
Main (U.S. Coast Guard Station No. 409)	0.12M
Main	0.45M
Main	0.91M
Main	1.48M
Main	1.78M
Main	2.18M
Main	2.43M
Main	4.02M
Main	4.96M
Main	6.57M
West	0.15W
West	0.71W
West	0.90W
West / Waterford Creek	1.86W-WC
West	2.24W
West / Waterford Creek	2.29W-WC
West	2.44W
West / Waterford Creek	2.70W-WC
West	2.72W
West	3.65W
West	3.71W
West	4.72W
East / Bosserman Creek	2.45E-BC
East	3.03E
East / Bull Ditch	4.43E-BD
East / South Arm	4.78E-SA
East / Bull Ditch	4.94E-BD
East / Brown Ditch	5.99E-BrD
East / Gropp Ditch	6.46E-GD
East / Bull Ditch	7.04E-BD

The *E. coli* sampling data were collected on 169 different dates between the period of March 18, 1998 and October 3, 2002. The sources for the data include National Pollution Discharge Elimination System reporting records, the LaPorte County Health Department, the IDEM, the Indiana Department of Natural Resources, and the Michigan City Sanitary District. Rainfall data for each sampling date were also obtained from the J.B. Gifford Wastewater Treatment Plant (WWTP; river mile 1.78M). *E. coli* data collected from the WWTP outfall on six different dates in 1997 were available but not utilized in the analysis as the data were not representative of in-stream *E. coli* conditions.

The *E. coli* data for each sampling location and date were initially compared to the amount

of rainfall (between 0.00 and 0.88 inches) that occurred on the sampling date. Subsequently, the *E. coli* data were sorted by their collection date and respective Trail Creek branch into three general weather events: a dry event, the 1st quartile ("first flush") of a rain event, and the remaining portion of the rain event that occurred beyond the 1st quartile.

A dry event was defined as no rainfall on the sampling date and for 3 days prior to the sampling date. A rain event was defined as beginning with a rainfall date and ending with three successive dry dates. The 1st quartile of a rain event ("first flush") was defined as the group of dates within a rain event in which the first 25% of the total rainfall occurred (in some rain event cases, there was only one date for the 1st quartile when a 1-day rainfall was followed by three successive dry dates). An entire day's rainfall was incorporated within the 1st quartile if 25% of the total rainfall was reached prior to the end of the day. The 1st quartile ("first flush") was utilized as a separate weather event based on the concept that storm water that initially runs off pervious or impervious surface areas will have a higher concentration of *E. coli* than storm water that runs off later, after the rainfall has "cleansed" the area.

After sorting the *E. coli* data according to the above, the data were graphed versus sampling location within a creek branch. The geometric mean and the 95% confidence interval of the mean of each sampling location's dataset were also calculated and graphically shown. In addition, the *E. coli* data were compared with the 327 Indiana Administrative Code (IAC) 2-1-6 Section 6(d) water quality standard of 125 colonies per 100 milliliters (col/100 ml), which represents a geometric mean based on not less than five samples. However, the sample collection dates are not spaced over a 30-day period, which is also a 327 IAC 2-1-6 criterion; therefore, *E. coli* data are also compared to the maximum standard of 235 col/100ml.

EVALUATION OF RESULTS

Figures 2 through 5 present *E. coli* concentration versus rainfall/flow and/or Trail Creek river mile (sampling location). These figures are found in Attachment A for the cumulative years 1998 through 2001. Attachment B presents figures of stream flow for 1998 through 2001 (based on U.S. Geological Survey measurements near the Trail Creek discharge to Lake Michigan [Gage No. 04095300], daily rainfall, and *E. coli* sampling dates. Probability distributions of the available data (by sampling location) are found in Attachment C.

The *E. coli* concentrations are presented on a log-scale and the x-axis scales for sampling location are true-linear to better represent the actual location of *E. coli* samples (and potential problem areas) within the watershed branch that is analyzed. Finally, for select sampling locations, there was only one measured *E. coli* concentration for the particular weather event. In these cases, there are no confidence intervals bordering the geometric mean (dashed line).

Based on the available data presented, the following conclusions are made:

Attachment A Figures

Figure 2. 1998-2001 Trail Creek *E. Coli* Concentration versus Rainfall (24-hour period)

- The graph represents 993 *E. coli* sample concentrations. The results indicate

a weak increasing trend in *E. coli* concentrations throughout the Trail Creek watershed with increasing rainfall except for the largest rainfall events. However, the majority of lower *E. coli* concentrations for rainfalls greater than 0.8 inches occurred at sampling stations near the discharge point of Trail Creek where locations are subject to backwater and negative flows (dilution) due to Lake Michigan. In general, the *E. coli* data is highly variable with respect to rainfall and suggests constant loadings of *E. coli* and frequent violations of state standards.

Figure 2A. 1998-2001 Trail Creek *E. Coli* Concentration versus Flow

- The graph represents the 993 *E. coli* sample concentrations shown in Figure 2 as compared to Trail Creek flow (based on U.S. Geological Survey measurements near the Trail Creek discharge to Lake Michigan [Gage No. 04095300]). The results indicate that 327 IAC exceedances for *E. coli* in Trail Creek generally occurred during creek discharges greater than 175 cubic feet per second (cfs). The graph also shows frequent violations of state standards for *E. coli* occurring throughout a range of stream discharges (from approximately 35 to 175 cfs) except, for the most part, at sampling stations that are subject to dilution effects from Lake Michigan.

Figure 3. 1998-2001 Trail Creek Main Branch *E. Coli* Concentrations

- The graph represents virtually the entire main branch of Trail Creek from the confluence with the east and west branches to the discharge point at Lake Michigan. As shown for dry periods (blue-dashed line), the geometric mean of measured *E. coli* concentrations at six of six sampling locations is above the water quality standard until the 0.91M river mile where there is a noticeable decrease in the geometric mean concentrations. This is most likely due to the dilution effect associated with intruding Lake Michigan water.

- As shown for the first flush of a rain event (1st quartile; yellow-dashed line), the geometric mean of measured *E. coli* concentrations at four of four available sampling locations (two locations have only one concentration) is above the water quality standard until near the discharge point of Trail Creek is reached (0.12M river miles) where there are likely backwater effects from Lake Michigan. The first flush geometric mean is also higher than the dry event geometric mean between the 2.43M and 1.48M river miles.

- As shown for the remaining rain event after the 1st flush (red-dashed line), the geometric mean of measured *E. coli* concentrations at seven of eight sampling locations is above the water quality standard until near the discharge point of Trail Creek is reached (0.12M river miles). The geometric mean drops below the standard at the 4.96 river mile location. This location is just downstream from a less developed and forested area along the creek. A noticeable decrease in the geometric mean of concentrations also occurs at the 0.91M river mile for reasons not fully understood. The remaining rain event geometric mean is also higher than the dry event geometric mean from the 4.02M river mile and beyond. The geometric mean concentrations for the

remaining rain event are also higher within two creek reaches (river miles between 6.57M and 4.96M [mostly forested], and between 2.43M and 1.48M [forested and developed]) than the geometric means for the first flush (contrary to initial assumptions); this may be a function of the type and retention capacity of the soil and/or the presence of sanitary sewers in these areas.

- Potential Known Significant Sources for *E. Coli*: Upstream CFOs, Daphne Mobile Home Park, Town of Trail Creek septage systems, and Michigan City combined sewer outfalls (CSOs). However, there have been only ten days during the three-year period of 1998-2001 (May 6-15, 1998 and July 7-8, 1998) when recorded sewage overflows occurred in Trail Creek (*Summary Report* [dated August 2001] from the Point Source Committee Interagency Task Force on *E. Coli*). Both events were reported as low volume overflows (less than 2,000 gallons per day).

Figure 4. 1998-2001 Trail Creek West Branch *E. Coli* Concentrations

- The graph represents the primary west branch of Trail Creek (other than Waterford Creek) from the confluence of the west and main branches to a point 4.72 river miles upstream. As shown for dry periods (blue-dashed line), the geometric mean of measured *E. coli* concentrations at five (farthest upstream) of seven sampling locations (two locations have only one concentration) is above the water quality standard.

- As shown for the first flush of a rain event (1st quartile; yellow-dashed line), the geometric mean of measured *E. coli* concentrations at all five available sampling locations is above the water quality standard for virtually the entire west branch.

- As shown for the remaining rain event after the 1st flush (red-dashed line), the geometric mean of measured *E. coli* concentrations at all nine sampling locations are above the water quality standard for the entire west branch analyzed. The geographic distribution of septage land applications could potentially be causing the sharp increase in the geometric mean of *E. coli* concentrations between the 3.71W and 3.65W river miles. However, the geometric mean concentrations for the remaining rain event from this stream section and further downstream are higher than the geometric means for the first flush; this could be attributed, in part, to soil type and its retention capacity within the mostly agricultural/forested areas near the creek. The first flush geometric means are higher than the remaining rain event geometric means within the furthest downstream section of the sub-watershed.

- Potential Known Significant Sources for *E. Coli*: CFOs and permitted septage land application areas.

Figure 5. 1998-2001 Trail Creek East Branch *E. Coli* Concentrations

- The graph represents the primary east branch of Trail Creek (excluding the

minor tributaries such as Brown Ditch and South Arm) from the upstream river mile 7.04E-BD within Bull Ditch to the 3.03E river mile upstream from Bosserman Creek. As shown for dry periods, measured *E. coli* concentrations (all four sampling locations have only one concentration; blue-dashed line does not represent the geometric mean) are above the water quality standard for the entire reach analyzed.

As shown for the first flush of a rain event (1st quartile), measured *E. coli* concentrations (all four sampling locations have only one concentration; yellow-dashed line does not represent the geometric mean) are above the water quality standard for the entire reach analyzed.

As shown for the remaining rain event after the 1st flush (red-dashed line), the geometric mean of measured *E. coli* concentrations at all four sampling locations are above the water quality standard for the entire reach analyzed. Unlike the main and west branches, the first flush geometric means are higher than the remaining rain event geometric means within the entire east branch that is sampled. It is not clear what east branch conditions would create higher first flush concentrations than the west branch unless sources for *E. coli* such as CFOs were closer to sampling stations.

- Potential Known Significant Sources for *E. Coli*: CFOs, permitted septage land application areas.

Attachment B Figures

Figures 1 through 4. 1998-2001 Trail Creek Flow and Precipitation

The graphs qualitatively compare the 1998 through 2001 sampling dates with daily flow and rainfall. The results show that *E. coli* sampling occurred during a variety of flow rate and weather event conditions with average annual flows generally ranging between approximately 100 and 150 cfs. Sampling during three of the four years (1998-2000) also occurred on or near dates of higher flows ranging between approximately 300 and 870 cfs.

Attachment C Figures

In order to summarize the Trail Creek bacteria data collected between 1998 and 2001, probability distributions of the available data were developed by station. Probability distributions are useful for presenting the mean and variation of a data set, and also provide a means for determining compliance (percent exceedance) from Indiana standards. The method for developing the distribution is to rank the data set from lowest to highest, calculate a percentage for each point (i/n-1) and to plot the transformed data on a log-probability scale, which implies a log-normal distribution. The horizontal lines in these figures represent the 327 IAC *E. coli* geometric mean standard of 125 col/100mL (solid line) and maximum standard of 235 col/100mL (dashed line).

As highlighted in the figures (one for each sampling station), the state *E. coli* standards are frequently violated at all stations in the Trail Creek watershed. Percent exceedances of the

state geometric mean standard ranged from approximately 10-95% in the main branch of Trail Creek with the higher exceedances occurring upstream. In the west branch of Trail Creek, percent exceedances ranged from 80-100% and in the east branch ranged from 70-100%. Based on the probability distributions and the preceding data analyses, *E. coli* levels in the Trail Creek watershed are frequently violating Indiana standards and generally occur during all times of the year (wet or dry).

GENERAL CONCLUSIONS

- Exceedances of the 327 IAC water quality standard for *E. coli* (125 col/100 ml) occur throughout the Trail Creek watershed almost on a continuous basis.
- Exceedances of the *E. coli* standard occur during both dry and wet weather.
- Apparent sources for *E. coli* in Trail Creek are not limited to Michigan City and potentially include localized septage from subdivisions outside the City, agricultural animal farming, and land application of septage.

Please contact us if you have any questions.

Sincerely,

TRIAD ENGINEERING INCORPORATED

Tina A. Reese
Project Manager

TRIAD ENGINEERING INCORPORATED

David C. Nader, LPG, CGWP
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Attachments
c: Andrew J. Thuman, P.E./HydroQual, Inc.

ATTACHMENT A

E. COLI ANALYSIS GRAPHS

ATTACHMENT B

GRAPHS OF STREAMFLOW, RAINFALL, AND *E. COLI* SAMPLING DATES FOR 1998-2001

ATTACHMENT C

PROBABILITY DISTRIBUTIONS